Suspended Solids-Turbidity Correlation for Monitoring: Challenged Approach for Future Dredging Project in Thailand

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PTT Public Company Limited., PTT, is the national oil & gas company that played an important role in strengthening Thailand's energy security by transporting natural gas from Gulf of Thailand and also imported gas to various customers in industrial, commercial and transporting sectors through onshore and offshore pipeline systems since 1981. However, the demand according to Power Development Plan (PDP) has increased gradually; PTT decides to construct a new Liquefied Natural Gas (LNG) receiving terminal for gas security. After site comparison and analysis, Maptaphut coast, which is located in the east, has an advantage to be selected. Preliminary environmental impact assessment stated that suspended solids (SS) during dredging, disposal and resuspension is the significant impact due to increased turbidity may reduce the light penetration to aquatic lives, cause growth reducing, and, in extreme conditions, may cause death. SS measurement is impractical to detect and correct short term problems or permit violations because of time consuming in testing, turbidity measurements are considered instead due to quickly and easily measured. However, there is no universal relationship between turbidity and SS, because of accuracy depend on site specific basis and certain techniques. Thus, turbidity measurement is often substituted for SS if the SS-turbidity curve has been completed prior commence dredging activity. After whole year study, through wet-dry period, the correlation curves are established for this proposed area and shall be subjected to uses as a real-time indicator of SS monitoring measures in the future.

Keywords: environmental impact, suspended solids, dredging, turbidity, monitoring measures

Abstract Summary Statement: Turbidity measurement is often used as a real-time indicator of suspended solids monitoring if the correlation curve in that place has been completed prior commence dredging activity.

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INTRODUCTION

Simple and quick turbidity measurement shall be considered as an operational aid in monitoring water quality because it's less costly and less time-consuming than suspended solid measurement. Although turbidity and suspended solids are related to each other, but should not be routinely substituted for the other due to the accuracy depend on site specific basis and certain techniques. The intention of this study is to assure that turbidity measurement shall be able to use as the preliminary guideline for onsite monitoring during dredging activity for future development project.

PROJECT DESCRIPTION

With response to Thailand gas securities, PTT has been seeking opportunity for a new Liquefied Natural Gas (LNG) receiving terminal to serve for future demands according to new Power Development Plan (PDP). Concerns to environments and societies, initial impacts were identified since performing site comparison and analysis. Maptaphut coast, where is located in the east, has been considered because of the readiness of existing infrastructures and related facilities. The significant impact is suspended solids (SS) occurred during dredging and disposal because of more turbidity increased, more risk to aquatic lives underneath. The less light penetration may cause growth reducing, and in extreme conditions, may cause death (Kerr, 1995). For some species that are filter feeder such as bivalvia, the growth shall be decreased when SS is increase to 50-100 mg/l, (Birtwell *et al.*, 2008). Salmonid species maybe reduce growth and migration because of not able to tolerate to turbidity more than 70 NTU (Bash *et al.*, 2001).

To prevent such problem, some authorities have issue specific regulation for protection of aquatic life such as Florida has regulated turbidity not over than 29 NTU for the sea grass area (Monroe County, 2001). Other countries such as Australia also has mitigation to protect the coral reefs by regulate SS from dredging not over than 199 mg/l (EPA, 2001). For Thailand, Notification of the National Environment Board No. 27, B.E. 2549 (2006) has regulated SS in coastal water not be changed by more than the sum of daily or monthly or yearly average and the standard deviation. Unfortunately, SS measurement is impractical to detect and correct short term problems or permit violations because of time consuming in testing, so the turbidity measurement is considered instead due to quickly and easily measured. The correlation curve between SS and Turbidity has been used for monitoring in many cases such as dredging at Sheboygan River and superfund site in Wisconsin US (Pollution Risk Services, LLC, 2010), port construction at Gladstone Ports in Western Basin Australia (Gladstone Ports Corporation, 2009) and Botany Port in Sydney Australia (Baulderstone Hornibrook, 2008). The third transmission pipeline project in Thailand has also implemented this mitigation measure by using correlation of SS at 1.2 times of NTU for monitoring near shore construction activity (PTT, 2010).

However, there is no universal relationship between turbidity and SS because the accuracy depends on site specific basis and certain techniques such as measurement by Turbidimeter or UV/VIS Spectrophotometer. Thus, SS-Turbidity correlation curve for this proposed project location should be studied and validated prior using in the future.

SCOPE OF STUDY / PROPOSED METHODOLOGY

1) Use statistic method (F-test & t-test) for checking variances and means of turbidity resulted from direct measurement by Turbidimeter and lab analysis by UV/VIS Spectrophotometer. If acceptable, the Turbidimeter shall be preferred for onsite measurement.
2) Identify sampling stations at 500 1,500 and 3,000 m from shore according to proposed dredging water channel (Figure 1).
3) Gathering secondary data thru wet and dry period from the coastal authority (Figure 2).

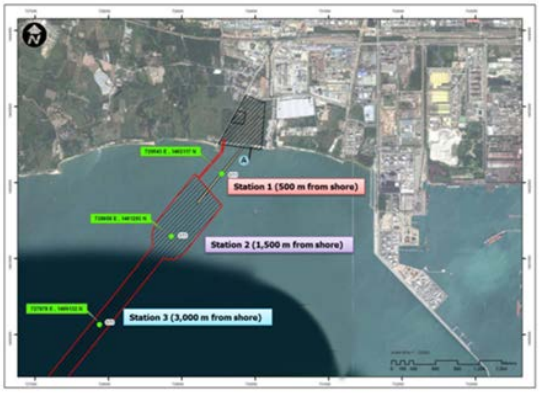


Figure 1 Sampling Stations

4) Navigating to target locations by GPS, grab sampling for sea water by Kemmerer sampler then analysis for SS and Turbidity thru wet period (May-Oct) and dry period (Nov-Apr). Also record the water depth at each location for reference

Figure 2 Monitoring Stations by Coastal Authority

5) Sampling sediment from the bottom seabed at each station by Petersen Grab Sampler (Figure 3).
6) Synthetic resuspension condition of each location in laboratory then measurement for SS and Turbidity (Thackston, *et al.*, 2000).
7) Build correlation curve between SS and Turbidity
8) Use statistic method (F-test & t-test) for checking variances and means of SS resulted from lab analysis and calculation from the correlation curve. Additional sampling may be required for validating this correlation curve.
9) Recheck variances and means (F-test & t-test) for assurance. If acceptable, use these data as the approved correlation curve

RESULT AND DISCUSSION

Sea Water Quality and SS standard

The monitoring results by coastal authority during 2009-2012 stated SS in seawater nearby project location varied between 2.5-219 mg/l whereas study during 2013-2014 show the results of SS at project location at 0.5-16.6 mg/l. Standard SS of each location (500 1,500 and 3,000 m from shore) shall be 10.1, 4.3 and 3.0 mg/l respectively during high tide and 10.8, 4.0 and 2.9 mg/l respectively during low tide.

Sediment Characteristic

The characteristic of sediment from each station are shown in Figure 3 and 4. Silt and clay are major components found at location near shore whereas sand is easily found far from shore.

ST1 @ 500 m from shore	ST2 @ 1,500 m from shore	ST3 @ 3,000 m from shore

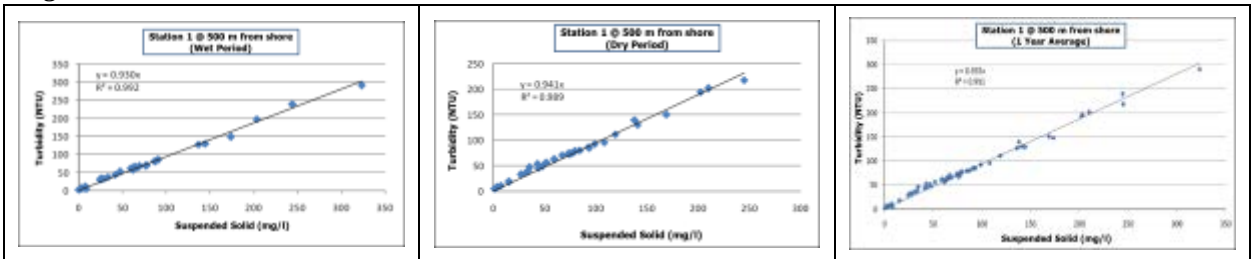
Figure 3 Characteristic of sediment along the dredging area (Sampling during wet period)

ST1 @ 500 m from shore	ST2 @ 1,500 m from shore	ST3 @ 3,000 m from shore

Figure 4 Characteristic of sediment along the dredging area (Sampling during dry period)

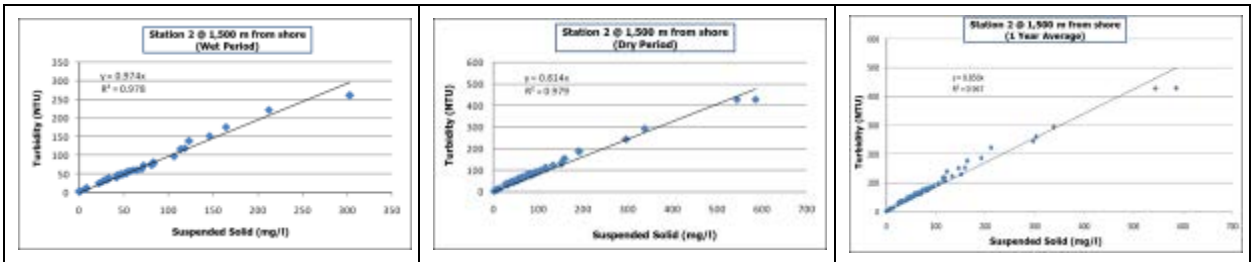
Correlation of SS and Turbidity

After turbidity analysis by using Nephelometric method comparative to portable Turbidimeter (EUTECH TN-100), the variable analysis confirm that portable Turbidimeter is able to substitute Nephelometric. SS were analyzed by Gravimetric Method then plot graph for correlation with turbidity. The correlations of SS and Turbidity for each location classified by season are shown as Figure 5 to 7.



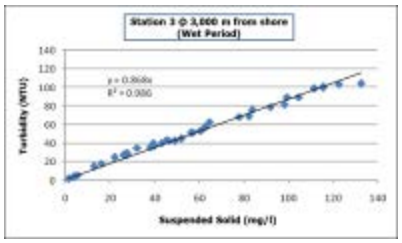
Wet Period	Dry Period	1 Year Average

Figure 5 Correlation curve of SS and Turbidity at Station 1 (500 m from shore)

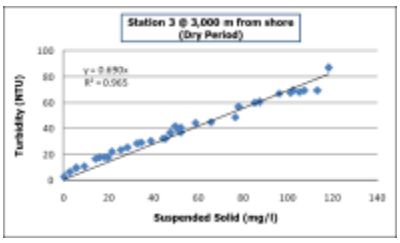


Wet Period	Dry Period	1 Year Average

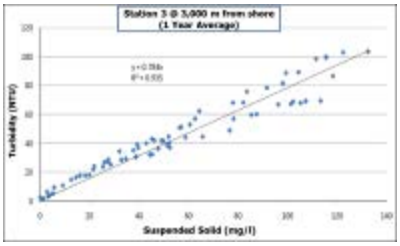
Figure 6 Correlation curve of SS and Turbidity at Station 2 (1,500 m from shore)



Wet Period



Dry Period



1 Year Average

Figure 7 Correlation curve of SS and Turbidity at Station 3 (3,000 m from shore)

Comparative to literature reviews, previous studies indicated that resuspension shall be occurred in bay and basin less than near shore. That is the reason why the coefficient of SS-Turbidity correlation in these studies are quite conservative. In general, sea water with sandy substrate has low turbidity because the large particles do not stay in suspension very long. Thus, dredging of coarse substrates which resuspend large solids might not violate turbidity standards. On the other hand, dredging fine sediments such as silt and clay shall cause more turbidity due to the substrate is easily suspended and settles slowly. However, because of the difficulties of SS measurements, turbidity is proposed to be an alternative measure. For convenient monitoring, Linear regression model was applied to develop this SS-Turbidity correlation curve to be software as shown in Figure 8.

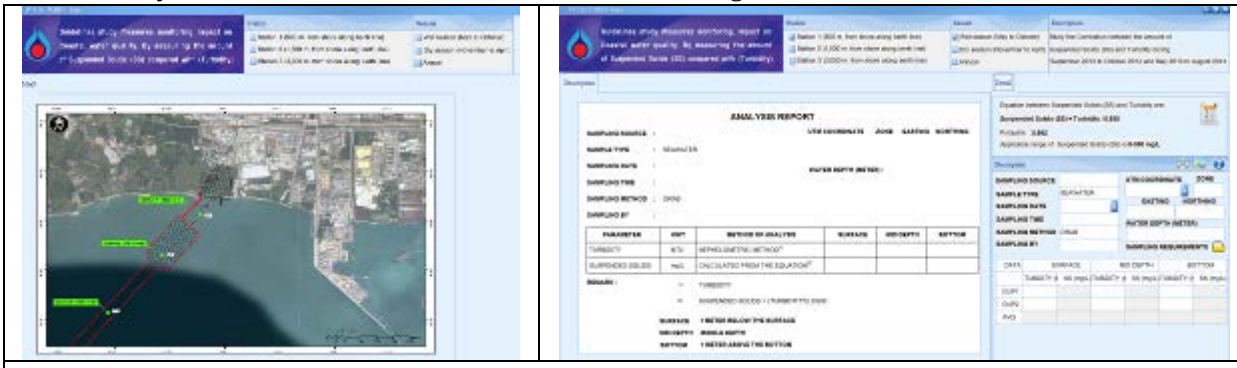


Figure 8 SS-Turbidity Correlation Software

CONCLUSION

In environmental view and legal standpoint, SS analysis is more accuracy because result is able to interpret in a meaningful manner. However for routine monitoring, turbidity is more preferable due to it's less costly and less time-consuming. This approach is to assure that turbidity shall be considered as an operational aid for onsite monitoring in case of site specific basis and certain techniques.

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